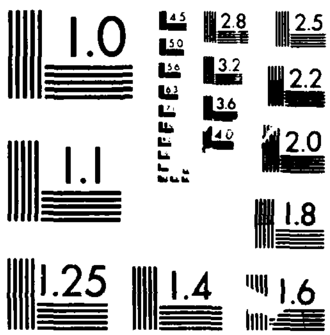
AD-A187 506 RESEARCH STUDIES ON EXTREME ULTRAVIOLET AND SOFT X-RAY 1/1
LASERS(U) STANFORD UNIV CA EDWARD L GINZTON LAB OF
PHYSICS S E HARRIS ET AL AUG 87 ARO-22842.15-PH
UNCLASSIFIED F49620-85-C-0101 F/G 9/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED MASTER COPY - FOR REPRODUCTION PURPOSES

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

DTIC FILE COPY

AD-A187 506

1a.	1b. RESTRICTIVE MARKINGS
2a.	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b.	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARO 22842.15-PH
6a. NAME OF PERFORMING ORGANIZATION: Stanford University — 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION U. S. Army Research Office
6c. ADDRESS (City, State, and ZIP Code) Stanford University Ginzton Laboratory Stanford, CA 94305	7b. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211
8a. NAME OF FUNDING / SPONSORING ORGANIZATION: U. S. Army Research Office — 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MIPR ARO 109-87
8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Research Studies on Extreme Ultraviolet and Soft X-Ray Lasers

12. PERSONAL AUTHOR(S)
S. E. Harris, and J. F. Young

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Annual Technical	FROM ____ TO ____	August 1987	6

16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Ultraviolet lasers, short wavelength lasers, extreme ultraviolet.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The goal of this program ~~is to~~ investigate, both theoretically and experimentally, new approaches to constructing XUV and soft x-ray lasers; it is a continuation and extension of our work sponsored by the predecessor contracts. This report covers the period from 1 September 1985 to 31 August 1986.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) — 22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

87 ... 22

ARO 22842.15PH

Contract F49620-85-C-0101
Air Force Office of Scientific Research
and the Army Research Office

Research Studies on Extreme Ultraviolet and Soft X-Ray Lasers

Annual Technical Report for the Period

1 September 1985 — 31 August 1986

Co-Principal Investigators:

S. E. Harris and J. F. Young

Edward L. Ginzton Laboratory
W. W. Hansen Laboratories of Physics
Stanford University
Stanford, CA 94305-4085
(415) 723-0224

Contract Monitor:
Dr. Howard Schlossberg
Building 410
AFOSR
Bolling Air Force Base
Washington, DC 20332

August 1987

Section 1

Introduction

The goal of this program is to investigate, both theoretically and experimentally, new approaches to constructing XUV and soft x-ray lasers; it is a continuation and extension of our work sponsored by the predecessor contracts. At these short wavelengths, atomic spontaneous emission times are typically less than a nanosecond and, for levels that autoionize, are often less than a few picoseconds. It is technically very difficult to excite such levels directly to produce laser action in the way that is commonly done for visible laser levels. Practical short wavelength lasers will have a significant impact in many areas; applications include spectroscopy of surfaces, high resolution lithography, microscopy, and holography.

The realization of the great promise of such applications, however, depends of the properties and practicality of the lasers developed. Although there is a 20 year history of proposals for XUV and soft x-ray lasers, most approaches require very high pumping powers. We have developed systems which can produce useful gain using only moderate input energies by combining the unique properties of particular atomic states with innovative experimental techniques. Thus, the program has consisted both of atomic spectroscopy studies, and exploration of new pumping techniques and geometries.

Our basic pumping technique makes use of a laser-produced plasma as a source of incoherent soft x-rays. This x-ray flashlamp photoionizes atomic core electrons producing populations in highly excited states. Our early work demonstrated that this process, combined with a new geometry with the gain species surrounding the plasma target, could produce very large excited state densities with moderate input energies. Populations in excess of $10^{15}\,\mathrm{cm}^{-3}$ were produced using less than 0.2 J of 1064 nm energy on target.

The program during this period emphasized a particular excitation process: photoionization of a core electron followed by Auger decay to produce direct inversions.

These types of systems are particularly interesting because the decay is highly selective in some cases; yields as high as 25% into particular levels are possible. Thus, significant gains can be achieved using only a few joules of laser pumping energy, rather than kilojoules. We first identified and proposed such systems in Zn, Rb, and Cs, and began experimental projects.

Section 2 itemizes some of the particular results of our work under this program, and Section 3 lists publications based on supported work. This program of research is jointly funded by other agencies, including ONR, LLNL, and SDIO.

Section 2

Summary of Accomplishments

The list below summarizes our important results during this contract, and its predecessors, of our program to create new short wavelength lasers.

1. Our work on metastable store and transfer began in 1975 with the proposal for laser-induced collisions, followed by the first experimental demonstration of laser-induced dipole-dipole collisions, and laser-induced charge transfer collisions.
2. In 1977, we proposed spontaneous anti-Stokes scattering as a pump for XUV lasers, and as a high-resolution XUV radiation source.
3. The store and transfer method, based on quartet levels which lie above the continuum, was proposed in 1980.
4. Using a pulsed, high-power microwave discharge, the emission spectrum of core-excited Li (with intense emission at 207 Å, plus emission into the valence electron continuum) was observed.
5. Transfer from the $\mathrm{Li}(1s2s2p)\ {}^4P$ to the $\mathrm{Li}(1s2p^2)\ {}^2P$ level, thereby connecting the doublet and the quartet manifolds of Li, was achieved in 1981.
6. The spontaneous anti-Stokes Raman source was demonstrated and used to take the highest resolution spectrum of core-excited K to date.
7. Pulsed hollow-cathode discharge technology was developed and used to measure, for the first time, the populations of metastable quartet levels in neutral Li and Na.
8. In 1983, we demonstrated the use of laser-produced x-rays for pumping metastable levels of Li^+. Population densities of ions in excess of $10^{15}\,\mathrm{cm}^{-3}$ at $\sim 60\,\mathrm{eV}$ were obtained.
9. This was followed by the demonstration of the use of laser-produced x-rays to produce hot electrons which, in turn, excited the metastable storage levels of Li and Na. This

experiment also resulted in the first measurement of the metastability of quartet levels in the presence of hot electrons.

10. Using laser-induced fluorescence from metastable storage levels, we obtained a Grotrian diagram for core-excited Na.
11. The concept of quasi-metastability was proposed, and was demonstrated via the emission spectra of core-excited Cs.
12. We developed and proposed a new type of scheme for XUV lasers using Auger processes in Cs and Zn.
13. A new longitudinal pumping geometry using an ellipsoidal grazing incidence mirror was proposed.
14. A proof-of-principle experiment was performed using an ellipsoidal mirror to pump Cd.

Section 3

Supported Publications

1. K. D. Pedrotti, D. P. Dimiduk, J. F., Young, and S. E. Harris, "Identification and Oscillator Strength Measurement of the 109.1 nm Transition in Neutral Cs," *Opt. Lett.* **11**, 425–427 (July 1986).
2. D. J. Walker, R. G. Caro, and S. E. Harris, "Proposal for an Extreme Ultraviolet Auger Laser at 63.8 nm in Cs III," *J. Opt. Soc. Am. B* **3**, 1515–1517 (November 1986).
3. R. G. Caro, P. J. K. Wisoff, G. Y. Yin, D. J. Walker, M. H. Sher, C. P. J. Barty, J. F. Young, and S. E. Harris, "Soft X-Ray Pumping of Inner Shell Excited Levels for Extreme Ultraviolet Lasers," in *Short Wavelength Coherent Radiation: Generation and Applications*, D. T. Attwood and J. Bokor, eds. (New York: AIP, 1986), pp. 145–156.
4. J. F. Young, J. J. Macklin, and S. E. Harris, "Ellipsoidal Focusing of Soft X-Rays for Longitudinally Pumping Short Wavelength Lasers," in *Short Wavelength Coherent Radiation: Generation and Applications*, D. T. Attwood and J. Bokor, eds. (New York: AIP, 1986), pp. 86–88.
5. D. P. Dimiduk, K. D. Pedrotti, J. F. Young, and S. E. Harris, "Laser Spectroscopy of the 109.1 nm Transition in Neutral Cs," in *Short Wavelength Coherent Radiation: Generation and Applications*, D. T. Attwood and J. Bokor, eds. (New York: AIP, 1986), pp. 213–218.
6. J. F. Young, J. J. Macklin, and S. E. Harris, "Grazing-incidence ellipsoidal reflector for longitudinally pumping short-wavelength lasers," *Opt. Lett.* **12**, 90–92 (February 1987).
7. K. D. Pedrotti, "Extinction Spectroscopy: A Novel Laser Spectroscopic Technique," *Opt. Com.* **62**, 250–255 (May 1987).

END
Feb.
1988
DTIC